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Feasibility of Capturing and Marking Juvenile Coho Salmon for Stock Assessment in the Kenai River

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ABSTRACT

The feasibility of capturing and marking wild coho salmon *Oncorhynchus kisutch* juveniles was assessed as part of a program to estimate the exploitation rate of Kenai River early run adults. The recreational harvest is estimated annually, but the escapement and harvest in the commercial fishery are unknown. The goal of this study is to estimate the harvest of Kenai River coho salmon in the commercial fishery while a companion project is investigating techniques to estimate escapement. To allow identification of Kenai River adult coho salmon in the 1993 commercial harvest, juvenile coho salmon were captured at three locations in the Kenai River drainage and marked with coded, microwire tags and an adipose finclip.

Mainstem capture of smolt was attempted in the summer of 1991 near the outlet of Skilak Lake with nearshore modified fyke traps. Less than 100 coho salmon were captured and the method was abandoned.

Rearing fingerling were captured during the fall of 1991 near the outlet of Skilak Lake with nearshore modified fyke traps. Only coho salmon ≥ 72 mm in fork length were selected for marking to minimize the marking of age-0 fish. A total of 14,409 coho salmon were injected with tags and finclipped. After accounting for short-term tag retention (99%) and survival (99%) rates, 14,329 coho salmon were released with valid marks. Age-0 and age-1 were the predominant ages of coho salmon captured at the Skilak Lake location. The percentage of age-1 coho salmon decreased over time from 78% on 22 August to 15% on 29 October.

Coho salmon smolt were captured and marked as they emigrated from two tributaries during the spring of 1992. A weir was installed on the Moose River and coho salmon ≥ 100 mm were selected from the catch for marking between 22 May and 24 June. A total of 75,372 were injected with tags and adipose-clipped. After accounting for short-term tag retention (98%) and survival (99%) rates, 73,580 coho salmon were released with valid marks. A weir was also installed on Hidden Creek where a total of 21,773 smolt ≥ 100 mm were injected with tags and adipose-clipped between 19 May and 30 June. After accounting for short-term tag retention (100%) and survival (99%) rates, 21,544 coho salmon were released with valid marks. Smolt emigrating from both tributaries were predominantly age 2.

Coho salmon marked as fingerling at the outlet of Skilak Lake in 1991 were recaptured as smolt emigrating from both the Moose River and Hidden Creek in 1992. These fish accounted for 1.6% and 0.4% of the emigrations from the Moose River and Hidden Creek, respectively. Of 328 adipose-clipped smolt captured and inspected for implanted tags, 20% had no tag.

Marked coho salmon smolt were recaptured in inclined-plane traps at a site located in the Kenai River mainstem downstream of all release locations at river kilometer 32.0. Of 3,475 coho salmon captured, 838 (24%) were adipose-clipped. Of these adipose-clipped fish, 582 were inspected for a tag and 55 (9%) were missing the tag. Of the 527 fish with readable tags, 467 (89%) originated from Moose River, 38 (7%) from Hidden Creek, and 22 (4%) from Skilak Lake. The marked proportion of inclined-plane trap catches increased over time between 29 May and 30 June. Comparisons of length between release

at tributaries and recapture at river kilometer 32.0 indicate that inclined-plane traps were size-selective and biased toward smaller fish.

KEY WORDS: coho salmon, *Oncorhynchus kisutch*, fingerling, smolt, juvenile, Kenai River, Alaska, commercial contribution, exploitation, weir, fyke trap, microwire tag, coded wire tag, adipose-clip, tag retention, survival.

INTRODUCTION

Background

Upper Cook Inlet (Figure 1) coho salmon *Oncorhynchus kisutch* stocks support the largest sport harvests and the second largest commercial harvests for this species in the state of Alaska. Despite the size and importance of coho salmon fisheries in Upper Cook Inlet (UCI), there has been no comprehensive program to assess the status of contributing stocks. Commercial fisheries are managed primarily for sockeye salmon *O. nerka*, but coho salmon are harvested as a mixed-stock bycatch for which there is little substantive information concerning stock origins. Large, directed sport fisheries for coho salmon occur throughout Upper Cook Inlet. Although estimates of harvest are available for many sport fisheries, there is virtually no stock-specific information concerning the magnitude of total returns, exploitation rates, or spawning escapements.

Developing a baseline assessment of stock status is an implicit requirement for harvest management. Reconstruction of adult returns from harvest and escapement components is needed to provide such an assessment. The absence of escapement and stock-specific commercial harvest information has precluded such an assessment for major stocks that are subject to commercial and recreational harvest.

While there has been little investigation of escapements into UCI drainages, harvest surveys (Hammarstrom 1977, 1978 and 1988-1991; Mills 1979-1991) have been used to estimate annual sport harvests in many streams supporting coho salmon populations. In addition, techniques for quantifying stock-specific contributions to commercial harvests have been investigated. Initial analyses of length-at-age (Wadman *Unpublished*), migratory timing (Tarbox 1988), and scale pattern variables (Bethe *Unpublished*, Robertson 1979) indicated that these traits may be of value in estimating stock-specific contributions to commercial harvests. However, a recent study (Vincent-Lang and McBride 1989) concluded that they could be used only as general indicators of stock origins. It has not been feasible to use these traits to accurately quantify stock contributions to commercial fisheries.

Other stock identification methods were recently evaluated for their utility in quantifying the stock-origins of UCI commercial harvests (Meyer et al. 1991). It was recommended that juvenile coho salmon be captured from rearing streams and marked with coded, microwire tags to allow positive stock identification of returning marked adults in the mixed-stock harvest. Statistical procedures have been developed for allocating a harvest among contributing stocks based on recoveries of marked fish (Clark and Bernard 1987). These procedures have been applied in other commercial (Elliot et al. 1989, Elliot and Sterrit 1990) and recreational (Sonnichsen et al. 1987, Vincent-Lang et al. 1988, Carlon and Vincent-Lang 1989 and 1990) marine coho salmon fisheries in the state of Alaska.

As an initial step to assess UCI coho salmon stocks, the Kenai River has been selected for study. Currently, stock-specific harvest information is available for the inriver recreational harvest through ongoing creel surveys, but the contribution of Kenai River fish to the commercial marine harvest in Cook Inlet is yet unknown. The goal of this study is to estimate this

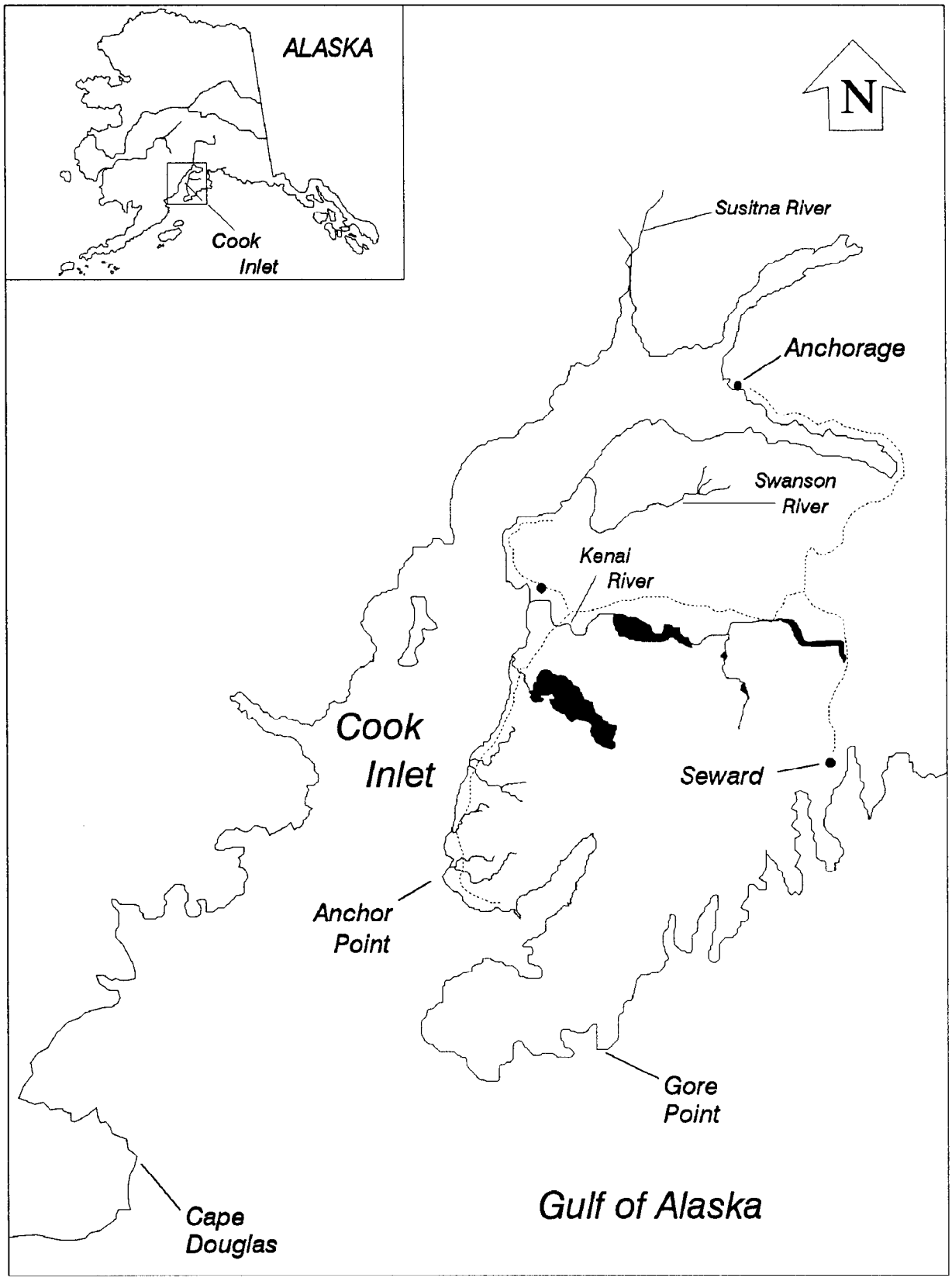

Figure 1. The Cook Inlet drainage, Alaska.

contribution using marked smolt from the Kenai River so that total fishing mortality can be estimated for the stock. A companion project is investigating the feasibility of enumerating the Kenai River coho salmon escapement using sonar technology.

Study Elements

There are three study elements essential to estimating the commercial harvest of Kenai River coho salmon. These are: (1) the marking of juvenile coho salmon captured within the Kenai River drainage, (2) the recovery of marked adults from the commercial and recreational harvests upon their return to spawn, and (3) the recovery of marked adults from the Kenai River recreational harvest for estimation of the tagging fraction of Kenai River coho salmon. To date, only the experimental marking of juveniles (1) has been accomplished and will be reported here. The first return and recovery of marked adults (2) is expected in 1993.

To obtain a marked population of Kenai River coho salmon juveniles, three strategies were investigated:

1. the capture of seaward migrating smolt from the mainstem during May and June of 1991,

2. the capture of rearing fingerling from the mainstem during August through October of 1991, and

3. the capture of seaward migrating smolt from selected tributaries within the Kenai River basin during May and June of 1992.

The mainstem capture of smolt (1) proved unsuccessful (Carlon *Unpublished*). Long net leads were anchored in the river channel and set to guide migrating smolt toward nearshore fyke traps. Variable current velocities rendered the leads ineffective, fewer than 100 smolt were captured, and the technique was abandoned. Strategies (2) and (3) proved more successful and form the basis of this report.

METHODS

Study Area

Juvenile coho salmon were captured at three sites within the Kenai River drainage on the Kenai Peninsula, Alaska (Figure 2). Fingerlings were captured in the mainstem during the fall of 1991 between river kilometer (rkm) 80.8 and the outlet of Skilak Lake (rkm 83.3). Smolt were captured in two second-order tributaries to the Kenai River during the spring of 1992. One smolt weir was located on Hidden Creek about 2.5 km downstream from the outlet of Hidden Lake. A second smolt weir was located on the Moose River about 8.3 km from its confluence with the Kenai River at rkm 60.5.

The Commercial Fisheries Division operated a series of inclined-plane traps in the mainstem of the Kenai River (rkm 32.0) to study sockeye salmon smolt from mid-May through June 1992. The incidental trap catch of coho salmon at this location was examined for marked individuals released at upstream locations.

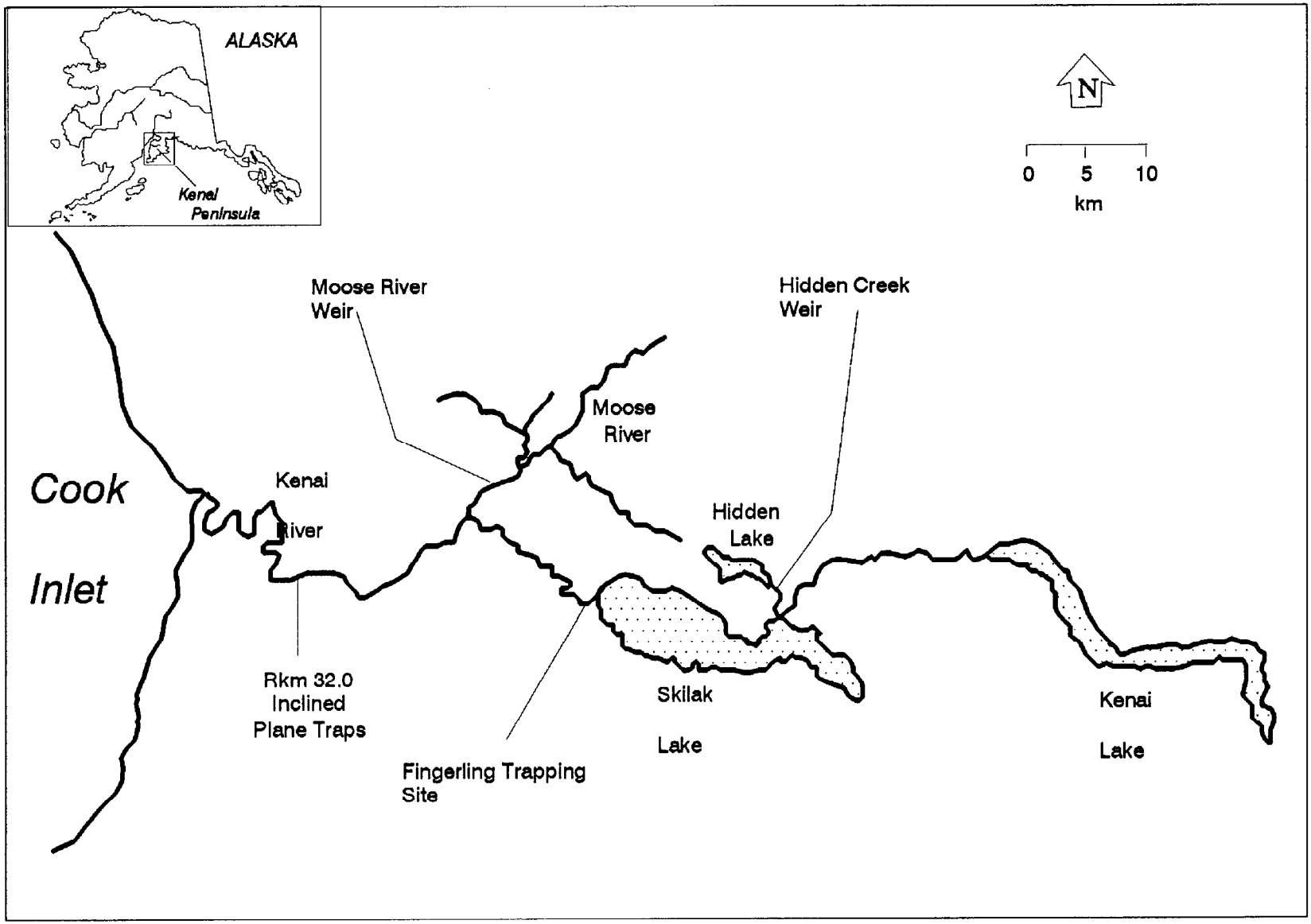

Figure 2. The Kenai River drainage showing coho salmon trapping locations.

Study Design

There is a wide range of run timing exhibited by adult coho salmon returning to the Kenai River. Some coho salmon enter the river as early as mid-July and others have been observed spawning as late as April of the following year. Inriver sport fishery performance (Hammarstrom 1988-1991) indicates that abundance from mid-July through late September is bimodal with an early run that peaks during mid-August and a late run that peaks during mid-September. Commercial drift and set net fisheries primarily exploit early run coho salmon in UCI between late June and mid August, after which the set net fishery closes by regulation and drift net fishing effort decreases due to low fish abundance (P. Ruesch, Alaska Department of Fish and Game, Soldotna, personal communication).

Other drainages such as the Susitna River, the Swanson River, and various tributaries on the west side of Cook Inlet support coho salmon stocks exhibiting early run timing. Because commercial fisheries harvest mixed-stock, early run fish, the management of early run stocks is of greater concern than late run stocks. As such, it would be expedient to mark only juveniles exhibiting the early run timing trait. However, it is not possible to determine adult run timing based on a visual inspection of juveniles. Therefore, an attempt was made to mark all juveniles captured. However, on numerous occasions, the number of juveniles captured emigrating from tributaries exceeded daily holding and marking capacities. On these occasions, surplus fish were enumerated and released without marks.

To estimate the commercial harvest of Kenai River coho salmon, it is necessary to estimate the proportion of the early run that is marked. This proportion will be estimated by examining a sample of the inriver sport harvest of returning adults in 1993 and assuming that it represents the marked proportion available to commercial fisheries. The sport harvest will be sampled over time to detect possible temporal changes in the marked proportion.

The capture of smolt from the mainstem Kenai River downstream from major tributaries probably offers the best opportunity to intercept and mark a representative sample of all Kenai River juveniles. However, suitable techniques have not yet been developed for capturing large numbers of coho salmon smolt from the mainstem and alternative strategies were used to obtain samples for marking. Recent studies indicated that juveniles are susceptible to capture from low velocity areas in the mainstem prior to overwintering (Bendock 1989) and as smolt emigrating from tributaries within the Kenai River basin (Fandrei 1991a, 1991b; Litchfield and Flagg 1988). This information was used to select strategies for juvenile capture and tag deployment.

Localized capture methods may result in marking bias. Preliminary indicators of marking bias were examined by testing for homogeneity of age and length compositions among capture locations used in 1992. Differences in these biological traits among locations could be indicative of discrete populations of rearing fish. Within-system recoveries of marked fish were also examined as preliminary indicators of marking bias.

Juvenile Capture and Tag Deployment

Captured fish were marked and released at three sites within the Kenai River drainage: the outlet of Skilak Lake, Moose River, and Hidden Creek.

Skilak Lake Outlet (Fingerling):

Modified fyke traps similar to those used by Bendock (1989) were set in the Kenai River mainstem at nearshore locations near the outlet of Skilak Lake (Figure 3) between 21 August and 31 October 1991. Cube-shaped trap frames were constructed of 1.3 cm concrete reinforcement bar, covered with 0.6 cm hardware cloth, and measured 1.2 m along each edge (Figure 4). Two vertical-slot openings on one face were 3.8 cm wide and allowed fish to enter the trap. Traps were set offshore in up to 1.1 m of water with the openings facing the shore. A knotless nylon seine (1.0 cm mesh) was attached to each trap, pulled taut, and affixed to shore to effectively block fish passage between the trap and the shore. Wing leads were added to direct fish into the trap. The shore and wing leads were stabilized using sandbags and 2.5 cm diameter pipe pounded into the stream bed.

Most Kenai River coho salmon smolt after 2 years in fresh water (Hammarstrom 1988-1991). To minimize the time marked fish would rear in the system before smolting, the marking of young-of-the-year (age-0) coho salmon was minimized. A threshold fork length (FL) of 72 mm was established from length and age data collected on 22 August prior to marking. This length was two standard deviations less than the mean length of age-1 coho salmon. Only coho salmon $\geq$ 72 mm were selected for marking while smaller fish were released untagged. Four traps were moved among locations to maximize the catch of coho salmon larger than 72 mm.

All fish were removed from traps with dip nets, placed in 22.7 L plastic buckets and transported by boat to a portable tagging facility at rkm 79.7. Coho salmon $\geq$ 72 mm were selected from the buckets and retained in 136 L plastic tubs supplied with circulating river water. All other fish were released. Fish retained were anesthetized with MS-222® and adipose finclipped (adipose-clip). A full length microwire tag was injected into the snout of each fish with a Northwest Marine Technologies® Mark IV tag injector. Standard handling and marking procedures were used (Moberly et al. 1977). Marked fish were released into the river after recovering from anesthetization. Tag codes were changed every 2 weeks during the tagging period.

Short-term tag retention and survival rates were estimated for fish marked each day by detaining a sample of about 200 marked fish in an inriver holding pen. The holding time ranged from 18 to 86 hours. On days when less than 200 fish were marked, all were detained. After at least 18 hours, the holding pen was checked for mortalities and the remaining live fish were passed through a tag detector to estimate short-term tag retention and survival.

Moose River (Smolt):

A smolt weir installed on the Moose River at rkm 9.3 (Figure 5) was operational from 22 May through 24 June 1992. The river is approximately 14 m wide at the weir location. Traps were set adjacent to each riverbank to trap

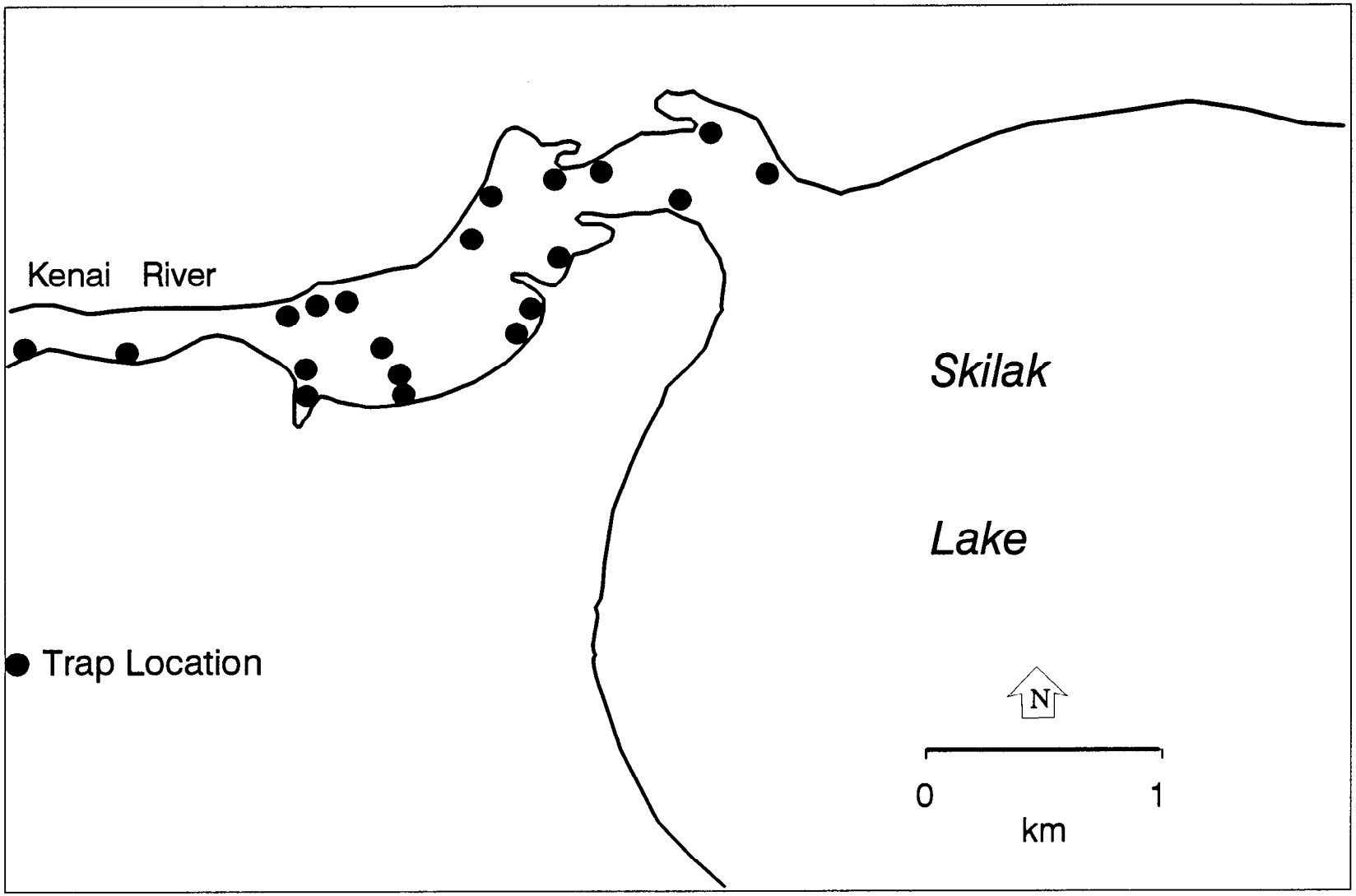

Figure 3. Fyke trap locations near the outlet of Skilak Lake, 1991.

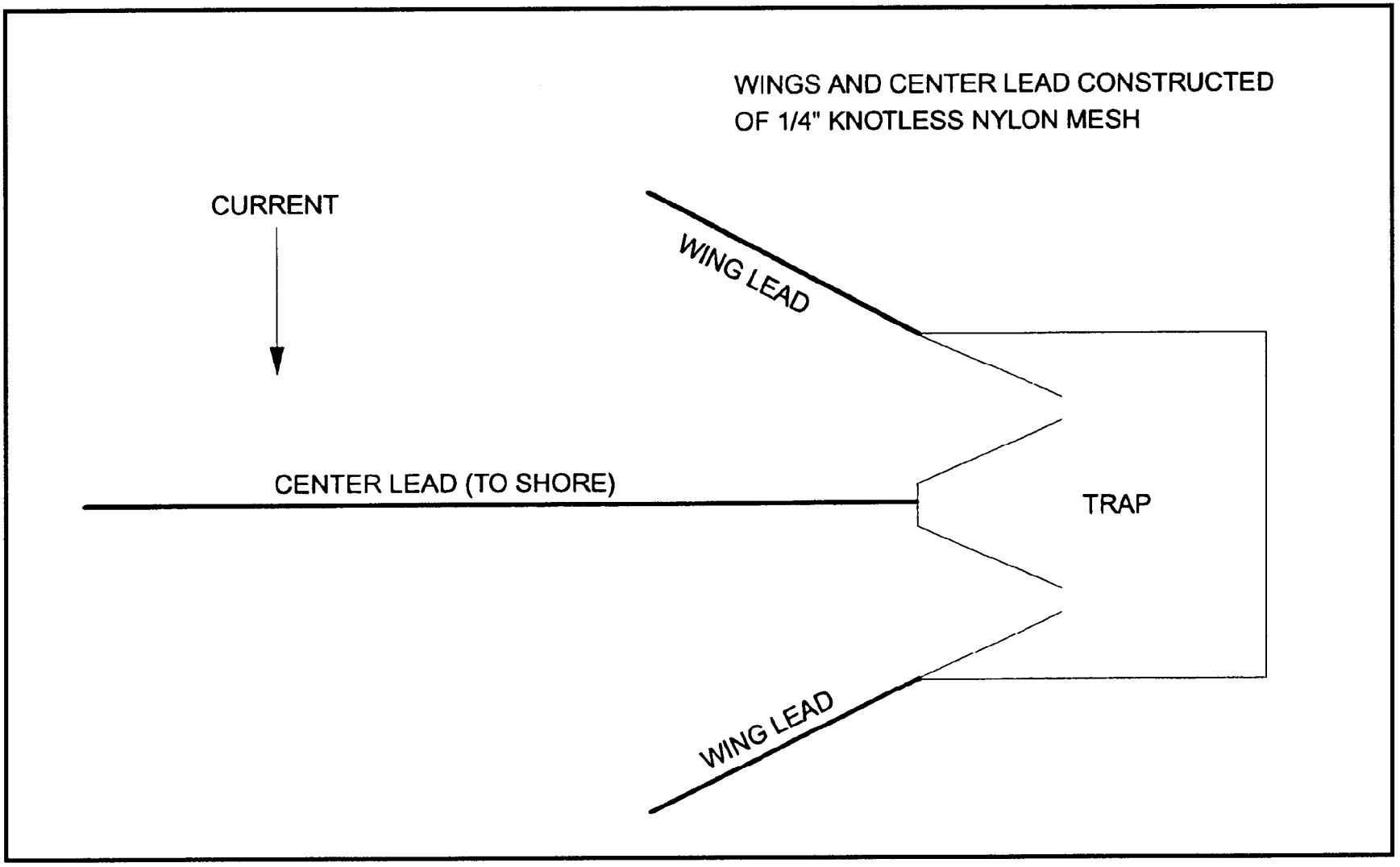

Figure 4. Schematic diagram of fyke traps used in the Kenai River near the outlet of Skilak Lake, 22 August through 31 October 1991.

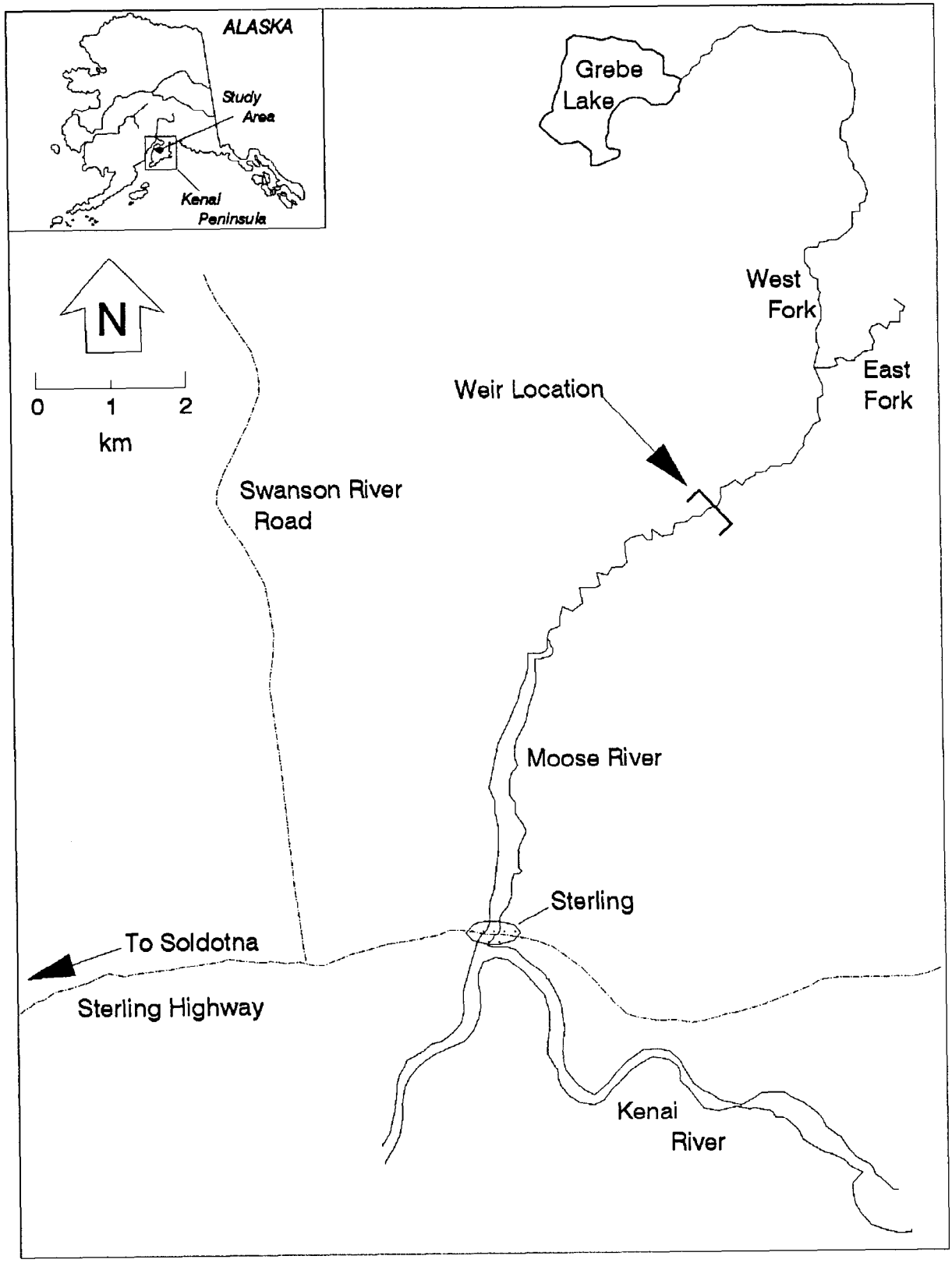

Figure 5. Location of the Moose River weir, 1992.

and pass all species of fish moving up or downstream. The upstream migrant trap was set about 6 m upstream of the downstream migrant trap.

Three rectangular panels made of rigid aluminum channel and measuring 3.6 m by 1.0 m were bolted together and supported in the stream against wooden tripods spaced about 2 m apart. Each end of the connected panels was secured to the trap adjacent to each bank. The aluminum channel was drilled to accept 1.25 cm solid aluminum rods which were inserted through the top channel, the bottom channel, and into the streambed. The gap between adjacent rods was 1.25 cm. Plastic mesh material (Vexar®) with a 1.27 cm mesh opening was used to cover the upstream surface of the weir panels and was held in place by water pressure.

Fish captured in the downstream migrant trap were counted by species. One or two people counted all trapped fish and selected coho salmon for marking. During May, virtually all downstream migrant fish trapped were larger than 100 mm. During June, small age-0 coho salmon were found in both the downstream and upstream migrant traps. Coho salmon $\geq$ 100 mm were selected for marking and all coho salmon $<$ 100 mm were released unmarked. All other species captured in the downstream migrant trap were released downstream of the weir, and those captured in the upstream migrant trap were released upstream of the weir.

Coho salmon selected for marking were temporarily retained in holding pens for a maximum of 36 hours. They were batch marked with unique codes in lots of about 1,200 to 6,200 per code. Fish were handled and marked using the same standard procedures used at Skilak Lake. During the peak migration period from 26 May through 7 June, two crews of two people each marked fish during two 7.5-hour shifts per day. During the remainder of the outmigration, one crew of two people marked fish during one shift per day. Fish in excess of what could be marked within 36 hours were counted and released unmarked.

Short-term tag retention and survival rates were estimated each day by detaining a sample of about 200 marked fish for 18 hours in an inriver holding pen. After 18 hours, the sample was checked for mortalities and most or all of the remaining live fish were passed through a tag detector. On several occasions, the total number of fish detained was not recorded and a true survival rate estimate was not possible. In these cases, the number of mortalities was added to the number of live fish tested for tag retention to estimate a minimum survival rate.

Hidden Creek (Smolt):

A smolt weir has been used to count sockeye and coho salmon smolt emigrating from Hidden Creek each year since 1976. On 14 May 1992, the weir was installed approximately 2.5 km downstream from the outlet of Hidden Lake (Figure 6). The stream is about 3.6 m wide at the weir location and water depth varies in the spring from 0.3 m to 0.4 m. The weir was operated by Cook Inlet Aquaculture Association personnel from 14 May until 14 July.

The fyke-type weir was constructed of knotless nylon net with circular mesh openings with a diameter of 1 cm. Fyke wings were about 4.5 m long and were

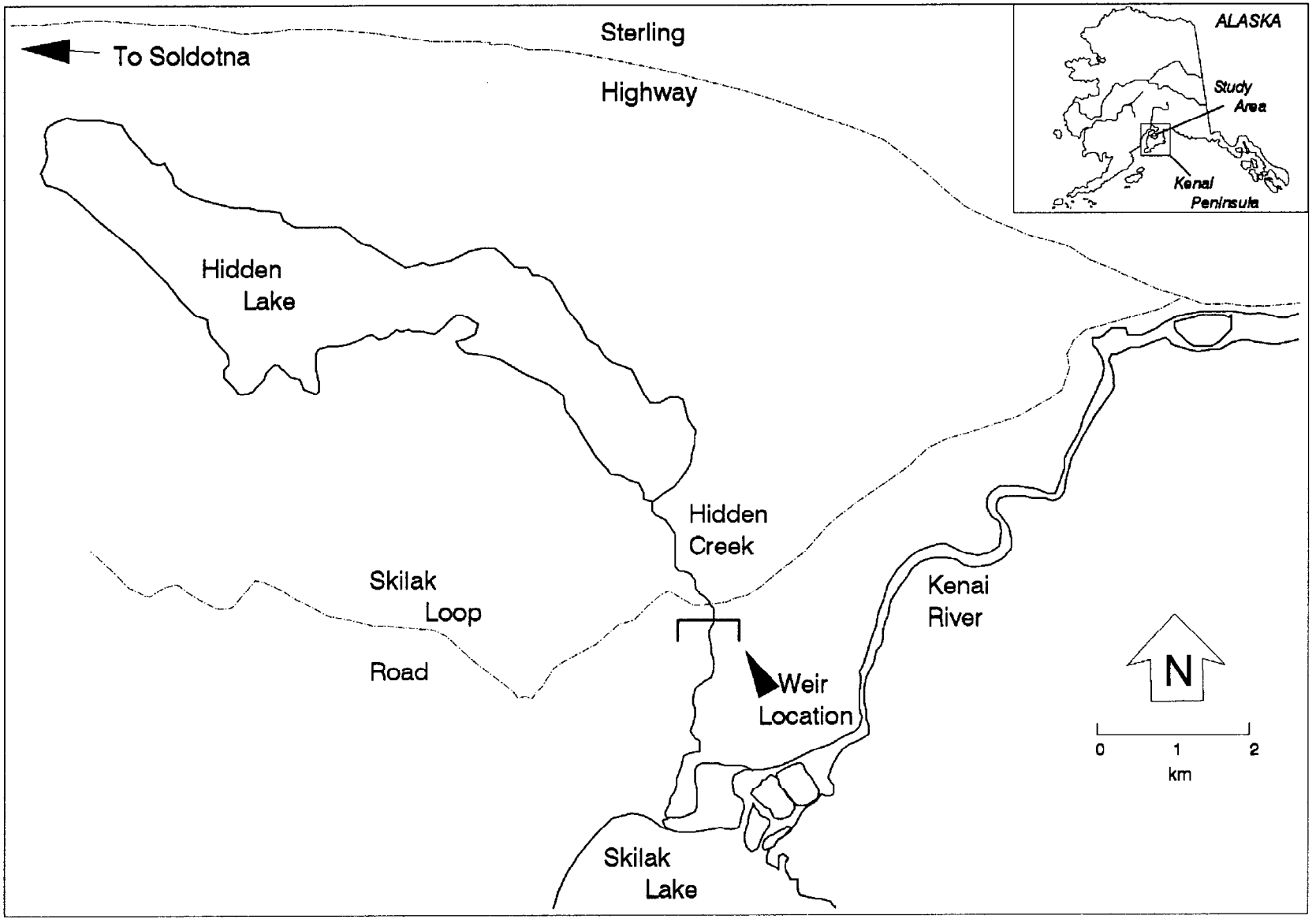

Figure 6. Location of the Hidden Creek weir, 1992.

attached to either bank. The wings converged at a circular opening in the net near midchannel downstream from the bank attachment points. The wings were stabilized with sandbags and 2.5 cm diameter pipe set into the streambed.

A cube-shaped trap measuring 1 m along each edge was fastened to the circular opening in the net to trap and hold fish migrating downstream. The trap was constructed of perforated aluminum plate and aluminum angle. A partition divided the trap into two holding areas and a hinged trap door controlled the flow of water and fish into each area.

Each partition was equipped with a removable panel allowing fish to pass freely through the trap. I was concerned about the effects of holding large numbers of smolt behind the weir during peak migration periods, therefore, fish passage was estimated during these times by periodically trapping and counting a timed sample in one partition and allowing fish to flow freely through the other partition for a timed period. Timed counts were then expanded by species to account for time periods when fish passed uncounted through the traps.

One crew of two people counted migrant fish and selected coho salmon larger than or equal to 100 mm for marking. Fish were handled and marked using the same standard procedures used at Skilak Lake and Moose River. Fish were temporarily retained in holding pens for a maximum of 36 hours. A second crew of two people marked fish 5 days per week during one 7.5-hour shift per day. Fish were batch marked with unique codes in lots of about 120 to 6,000 per code. Fish in excess of what could be marked within 36 hours were released unmarked.

Short-term tag retention and survival rates were estimated each day by detaining a sample of approximately 200 marked fish for 18 hours in an inriver holding pen. After 18 hours, the sample was checked for mortalities and most or all of the remaining live fish were passed through a tag detector.

Tag Recovery

All coho salmon selected for marking at the Moose River and Hidden Creek weirs were inspected for a missing adipose fin prior to marking. All adipose-clipped fish found at the Hidden Creek location were dissected and examined for an imbedded tag. Approximately 20% of the adipose-clipped fish from the Moose River were dissected: from 22 May through 28 May, all adipose-clipped fish were dissected; from 29 May through 3 June, 20% were dissected; and from 4 June through 24 June, 10% were dissected.

All coho captured in inclined-plane traps at rkm 32.0 were also examined for a missing adipose fin. From 29 May through 5 June, and from 13 June until 30 June, all adipose-clipped fish were dissected for tag inspection. From 6 June through 12 June, a systematic sample of 20% was dissected.

Length and Age Sampling

Fork lengths and scales were obtained from samples of fish at all four capture locations to estimate length and age compositions, to apportion the emigrations by age, and to compare length compositions of marked fish among capture locations. A scale smear was removed from the preferred area of each

sampled fish (Clutter and Whitesel 1956) and placed on adhesive-coated cards. Scale impressions made in clear acetate cards were examined with a microfiche reader to determine age.

Coho salmon sampled for age and length were randomly selected at various time intervals at all capture locations. Sampling during each interval involved collecting at least 200 fish in 1 or 2 days. When fish abundance was low, sampling occurred over several days, and on two occasions, less than 200 total fish were sampled. In addition, fork lengths and scales were systematically sampled from 40 coho salmon per day at Hidden Creek.

Data Analysis

Data analysis included both estimation of parameters and hypothesis testing. Estimated parameters included survival and tag retention rates, the number of fish released that retained tags, and length-age composition. Hypothesis testing was used to determine if samples could be pooled to provide more precise estimates and to compare length distributions between release and recovery locations.

Survival and Tag Retention Rates:

For each of the three release locations, the short-term survival rate (S_i) of fish marked and released each day was estimated as a binomial proportion by:

$$\hat{S}_i = n_i/n_{ti}, \qquad (1)$$

where:

n_i = number of marked fish detained on day i that survived the holding period, and

n_{ti} = number of marked fish detained.

The variance of survival was estimated by:

$$\mathrm{var}(\hat{S}_i) = \hat{S}_i(1-\hat{S}_i)/(n_{ti}-1). \qquad (2)$$

The short-term tag retention rate (R_i) for fish that were marked each day, survived, and retained tags was estimated similarly (as was the associated variance) where:

n_i = number of marked fish detained on day i that survived the holding period and retained a tag, and

n_{ti} = total number of marked fish that were detained on day i and survived the holding period.

Within each of the three release locations, a Kruskal-Wallis analysis of variance (Sokal and Rohlf 1969) was used to test the null hypotheses that survival and tag retention rates did not differ ($\alpha = 0.05$) among tag codes.

The Kruskal-Wallis tests determined if samples could be pooled among tag codes to provide more precise estimates of survival and tag retention.

Test results permitted pooling of daily survival samples over all days and a pooled short-term survival rate was estimated for each location. For the Moose River and Hidden Creek smolt releases, short-term tag retention rates did not differ among tag codes. Therefore, samples were pooled over all codes to calculate a single retention rate for each location. However, retention rates differed among the five tag codes released at Skilak Lake. Samples were pooled to estimate a single rate for three of the codes. The remaining samples were used to estimate retention rate for each of the remaining two codes.

Estimating Valid Marks Released:

Pooled estimates of short-term survival and tag retention were applied to the number injected by tag code group to estimate the total number of fish released with valid marks at all three release locations. All tag codes released at the Moose River were treated as one tag code group and codes released at Hidden Creek were treated as a second group. Tag codes released at Skilak Lake were assigned to one of three different groups for this purpose.

The total release of coho salmon with valid marks ($\hat{T}_j$) was estimated for each tag code group j by:

$$\hat{T}_j = N_j \hat{S}_j \hat{R}_j, \tag{3}$$

where:

N_j = the number of fish of tag code group j injected with a tag.

The associated variance was estimated (Goodman 1960) by:

$$\text{var}(\hat{T}_j) = N_j^2 \left[\hat{S}_j^2 \text{var}(\hat{R}_j) + \hat{R}_j^2 \text{var}(\hat{S}_j) - \text{var}(\hat{R}_j)\text{var}(\hat{S}_j)\right]. \tag{4}$$

To estimate releases by tag code c ($\hat{T}_{cj}$), the total release was apportioned by:

$$\hat{T}_{cj} = p_{cj} \hat{T}_j, \tag{5}$$

where:

$\hat{T}_{cj}$ = release of fish with valid marks of tag code c in tag code group j, and

p_{cj} = proportion of tag code c injected relative to all tags of group j injected.

The associated variance was estimated by:

$$\widehat{var}(T_{cj}) = p^2_{cj}\widehat{var}(T_j). \quad (6)$$

In the case of the two Skilak Lake tag code groups that included only one code, $p_{cj} = 1$. To determine the total number of fish released with valid marks at Skilak Lake, estimates and their variances were assumed independent and were summed over tag code groups.

Length and Age Sampling:

Samples used to compute age composition were collected at Skilak Lake during 2-week time periods (approximately) between 22 August and 29 October 1991. Samples collected at the other three locations represented 10-day periods with the exception of one 6-day period from 14 June to 19 June 1992.

The proportion of age group h present at each location during time period k $(\widehat{a}_{hk})$ was estimated by:

$$\widehat{a}_{hk} = n_{hk}/n_k, \quad (7)$$

where:

n_{hk} = number of coho salmon of age group h during time period k, and

n_k = number of readable scales sampled during time period k.

The variance of each proportion $\widehat{a}_{hk}$ was estimated by:

$$\widehat{var}(a_{hk}) = \widehat{a}_{hk}(1-\widehat{a}_{hk})/(n_k-1). \quad (8)$$

Differences in age compositions among time intervals were tested at each location using contingency tables and χ^2 tests at a significance level of 0.05. If differences were not detected, samples were pooled and used to estimate a more precise age composition for combined time intervals. Pooled age composition estimates were used to apportion the Moose River and Hidden Creek emigrations by age group.

Differences in age compositions were also tested between the Moose River location and the rkm 32.0 location and between the Hidden Creek location and the rkm 32.0 location. Differences in age composition could indicate trapping bias at rkm 32.0 or of the presence of smolt originating from areas other than Hidden Creek or the Moose River.

Mean length-at-age and associated variances were estimated using standard normal procedures. Differences in mean length-at-age were tested among time intervals at each location using analysis of variance at a significance level of 0.05. If differences were not detected, samples were pooled and used to estimate a more precise mean length-at-age for combined time intervals. Mean length-at-age was also compared among the three capture sites used in 1992.

Differences between the Moose River and Hidden Creek locations may be indicative of discrete populations of rearing fish. Differences between the release locations and the rkm 32.0 location may be indicative of sampling bias at rkm 32.0 or the presence of smolt originating from areas other than Hidden Creek or Moose River.

The cumulative length distribution of all fish sampled at Moose River was compared with the length distribution of marked Moose River fish recaptured at the rkm 32.0 location using the two-sample Kolmogorov-Smirnov test (Daniel 1978). The same comparison was made between all fish sampled at Hidden Creek and marked Hidden Creek fish recaptured at the rkm 32.0 location. Differences between release and recovery may be indicative of size-selective sampling of the inclined-plane traps at rkm 32.0. The presence of smolt originating from areas other than Hidden Creek or the Moose River would have no effect on this comparison.

The potential for size bias in the recapture gear used at rkm 32.0 was also examined by comparing the estimated mean length-at-release with the mean length-at-recapture at rkm 32.0 for individual tag codes. All comparisons were made using t-tests at a significance level of 0.05.

Tag Recovery:

Marked coho salmon were recovered in 1992 at the Moose River, Hidden Creek, and the rkm 32.0 inclined-plane traps. Marked coho salmon recovered at Moose River and Hidden Creek originated from the 1991 release of marked fingerlings at the outlet of Skilak Lake. Marked fish recovered at the rkm 32.0 inclined-plane traps originated from the 1992 Moose River/Hidden Creek smolt releases or from the 1991 Skilak Lake fingerling release.

The proportion $(\hat{p})$ of marked fish recovered at each location was estimated by:

$$\hat{p} = n/n_0, \tag{9}$$

where:

n = number of adipose-clipped fish examined at the capture location, and

n_0 = total number of fish examined at the capture location.

A comparison of the marked proportions emigrating from the tributaries was made using a contingency table and a χ^2 test at a significance level of 0.05. Failure to reject a null hypothesis of no difference in proportions would be indicative of a random dispersion of these fish from their original capture location at the outlet of Skilak Lake.

Temporal changes in the marked proportion of fish captured at rkm 32.0 would indicate that marks were not released in proportion to the abundance of all smolt. To detect differences, the numbers of marked and unmarked fish trapped by week were compared with a χ^2 test at a significance level of 0.05.

RESULTS

Coded Wire Tag Deployment

A total of 111,554 coho salmon juveniles were captured and injected with coded, microwire tags between 22 August 1991 and 30 June 1992. After adjusting for short-term tag loss and survival rates, an estimated 109,453 viable coho salmon retaining tags were released with one of 26 unique tag codes (Table 1). An estimated 14,329 fingerling were released at Skilak Lake, 73,580 smolt at the Moose River, and 21,544 smolt at Hidden Creek.

Single, location-specific estimates of short-term tag retention and survival rates were made for both the Moose River and Hidden Creek releases (Table 1). Test results indicated no differences in retention (Moose River: $\chi^2 = 16.58$, df = 14, P = 0.28; Hidden Creek: $\chi^2 = 0.00$, df = 5, P = 0.99) or survival (Moose River: $\chi^2 = 12.45$, df = 14, P = 0.57; Hidden Creek: $\chi^2 = 4.20$, df = 5, P = 0.52) rates among tag codes. All retention/survival samples were pooled to provide single estimates of tag retention and survival for each location.

Short-term survival rates did not differ among tag codes for the Skilak Lake releases ($\chi^2 = 4.08$, df = 4, P = 0.40), but short-term tag retention rates were different ($\chi^2 = 9.68$, df = 4, P = 0.05). Tag retention samples were pooled to the degree possible resulting in three separate estimates of tag retention and one estimate of survival (Table 1).

Coded Wire Tag Recovery

Recovery at Smolt Weirs:

A total of 165,175 coho salmon were enumerated as they emigrated from the Moose River between 21 May and 24 June 1992. Of these, 75,615 were examined for a missing adipose fin and 1,177 (1.6%) were found to be missing the fin. A total of 36,701 fish were enumerated as they emigrated from Hidden Creek between 16 May and 6 July 1992. Of these, 21,858 were examined for a missing adipose fin and 85 (0.4%) were found to be missing the fin. The marked proportions were significantly different between the two sites ($\chi^2 = 180.92$, df = 1, P < 0.001).

Of the 1,177 adipose-clipped fish recaptured at Moose River, 243 were retained and examined for an implanted tag. Of the 243 retained, 185 (76%) originated from the Skilak Lake fingerling release in 1991, 8 (3%) had been marked at the Moose River and released downstream of the weir, and 50 (21%) had no tag (Table 2). Apparently, there was a weir breech that allowed some fish to move upstream through the weir to be captured a second time. A summary of mark recoveries by date is presented in Appendix A1.

Of the 85 adipose-clipped fish recaptured at Hidden Creek, all were retained and examined for an implanted tag. Of the 85 retained, 64 (76%) originated from the Skilak Lake fingerling release, 5 (6%) had been marked at Hidden Creek and released downstream of the weir, and 16 (19%) had no tag (Table 2). As was the case at the Moose River, the recapture of recently marked and released fish indicated some upstream movement through a breech in the weir. A summary of mark recoveries by date is presented in Appendix A1.

Table 1. Estimated number of valid coded wire tags (T), 24-hour tag retention (R) and survival (S) rates, and associated standard errors (SE) for coho salmon fingerling marked at Skilak Lake in 1991 and smolt marked at Moose River and Hidden Creek in 1992.

Site	Release Period	Code	n[a]	Number Injected	Proportion of Total	T[b]	SE(T)	R	SE(R)	S	SE(S)
Skilak	8/23 - 9/03	312014	6	3,600	0.250	3,596	1.35	1.000	0.0000		
Lake	9/04 - 9/13	312015	7	3,688	0.256	3,667	4.45	0.995	0.0012		
1991	9/16 - 9/30	312016	11	4,336	0.301	4,296	8.67	0.992	0.0020		
	10/01 -10/14	312017	8	2,144	0.149	2,132	2.59	0.995	0.0012		
	10/17 -10/30	312018	4	641	0.044	637	0.77	0.995	0.0012		
		Total	36	14,409	1.000	14,329	11.75	0.995	0.0008	0.999	0.0004
Hidden	5/19 - 5/24	312131	5	120	0.006	119	0.19				
Creek	6/08 - 6/10	312134	3	1,353	0.062	1,339	2.11				
1992	6/10 - 6/15	312123	4	5,308	0.244	5,252	8.26				
	6/15 - 6/17	312030	3	5,968	0.274	5,905	9.29				
	6/17 - 6/24	312031	6	5,946	0.273	5,884	9.26				
	6/24 - 6/30	312032	5	3,078	0.141	3,046	4.79				
		Total	19	21,773	1.000	21,544	33.90	1.000	0.0000	0.990	0.0016
Moose	5/22 - 5/24	312132	3	1,207	0.016	1,178	2.08				
River	5/24 - 5/27	312124	4	5,763	0.077	5,626	9.93				
1992	5/27 - 5/28	312125	2	5,656	0.075	5,522	9.74				
	5/28 - 5/30	312126	3	5,804	0.077	5,666	10.00				
	5/30 - 5/31	312127	3	5,807	0.077	5,669	10.00				
	5/31 - 5/31	312133	1	859	0.011	839	1.48				
	6/01 - 6/02	312112	3	5,243	0.070	5,118	9.03				
	6/02 - 6/03	312113	3	5,294	0.070	5,168	9.12				
	6/03 - 6/04	312114	2	5,736	0.076	5,600	9.88				
	6/04 - 6/05	312115	3	5,666	0.075	5,531	9.76				
	6/06 - 6/09	312019	3	5,964	0.079	5,822	10.27				
	6/09 - 6/11	312020	3	6,191	0.082	6,044	10.66				
	6/11 - 6/13	312021	3	6,153	0.082	6,007	10.60				
	6/13 - 6/19	312022	4	6,112	0.081	5,967	10.53				
	6/19 - 6/24	312023	5	3,917	0.052	3,824	6.75				
		Total	29	75,372	1.000	73,580	129.81	0.983	0.0015	0.993	0.0010

[a] Number of days tag code was injected. Sum of days at a site may not equal total due to more than one tag code injected on a day.

[b] Sum of valid tags may not equal total due to rounding.

Table 2. Summary of recovered marked juvenile coho salmon by recovery and release location, Kenai River, 1992.

Recovery Location	Number Examined	Number of Adipose-clips	Number Inspected for CWT[a]	Number Without CWT[a]	Release Location		
					Skilak Lake, 1991	Moose River, 1992	Hidden Creek, 1992
Moose River	75,615	1,177	243	50	185	8	
Hidden Creek	21,858	85	85	16	64		5
Kenai River, rkm 32.0	3,475	838	582	55	22	467	38

[a] Coded wire tag.

Recovery at rkm 32.0:

A total of 3,475 coho salmon smolt were captured in inclined-plane traps located in the mainstem at rkm 32.0. All were examined for an adipose finclip and 838 (24%) adipose-clipped fish were found. Of the 838, a sample of 582 were retained and examined for an implanted tag. Of the 582 retained, 467 (80%) originated from the Moose River smolt release, 38 (7%) originated from the Hidden Creek smolt release, 22 (4%) originated from the Skilak Lake fingerling release, and 55 (9%) had no tag (Table 2). A summary of mark recoveries by date is presented in Appendix A2.

There was a significant difference ($\chi^2 = 167.70$, df = 4, $P < 0.001$) in the proportion of adipose-clipped smolt captured at rkm 32.0 over time. The proportion of adipose-clipped fish increased throughout the emigration (Figure 7).

Length and Age Sampling

Skilak Lake Outlet, 1991:

The population sampled at the outlet of Skilak Lake between 22 August and 29 October was composed primarily of age-0 and age-1 coho salmon (Table 3). Of 1,804 legible scales collected, only 15 were age 2. The proportion of age-1 coho salmon declined over time ($\chi^2 = 489.56$, df = 4, $P < 0.001$) from an initial high of 0.78 to a low of 0.09 on 16 October (Figure 8).

Although the mean length of age-0 coho salmon (Table 3) changed over time ($F = 10.12$, df = 4, 1,226, $P < 0.001$), mean length only ranged between 60 mm-63 mm. Likewise, mean length of age-1 fish was significantly ($F = 23.92$, df = 4, 553, $P < 0.001$) different among sampling periods due to a greater mean size on 30 September. The threshold length of 72 mm used to select fish for marking was calculated from the initial sample taken on 22 August. This threshold was two standard deviations (two sd = 23 mm) less than the mean fork length (95 mm) of age-1 coho salmon.

Smolt Weirs and rkm 32.0:

Coho salmon smolt sampled at the Moose River, Hidden Creek, and rkm 32.0 were predominantly age 2 (Table 4). The age composition of fish sampled at the Moose River ($\chi^2 = 11.02$, df = 6, $P = 0.09$) and rkm 32.0 ($\chi^2 = 8.10$, df = 6, $P = 0.23$) did not change over time. However, at Hidden Creek, age-3 and age-4 smolt predominated the first week of sampling and age-2 fish predominated thereafter. Age composition was estimated for two strata at Hidden Creek while all samples were pooled for Moose River (Table 5).

Mean length-at-age was compared among time periods to determine if samples collected at a given location could be pooled to more precisely estimate length-at-age (Table 6). Temporal samples were pooled if differences among periods were not detected, i.e. if $\alpha > 0.05$ (Table 7).

Comparisons of mean length-at-age indicated significant differences (range $F = 6.48$-27.32, $P \leq 0.002$) among locations. For all ages, the mean lengths of fish sampled at Hidden Creek were significantly larger than those sampled at

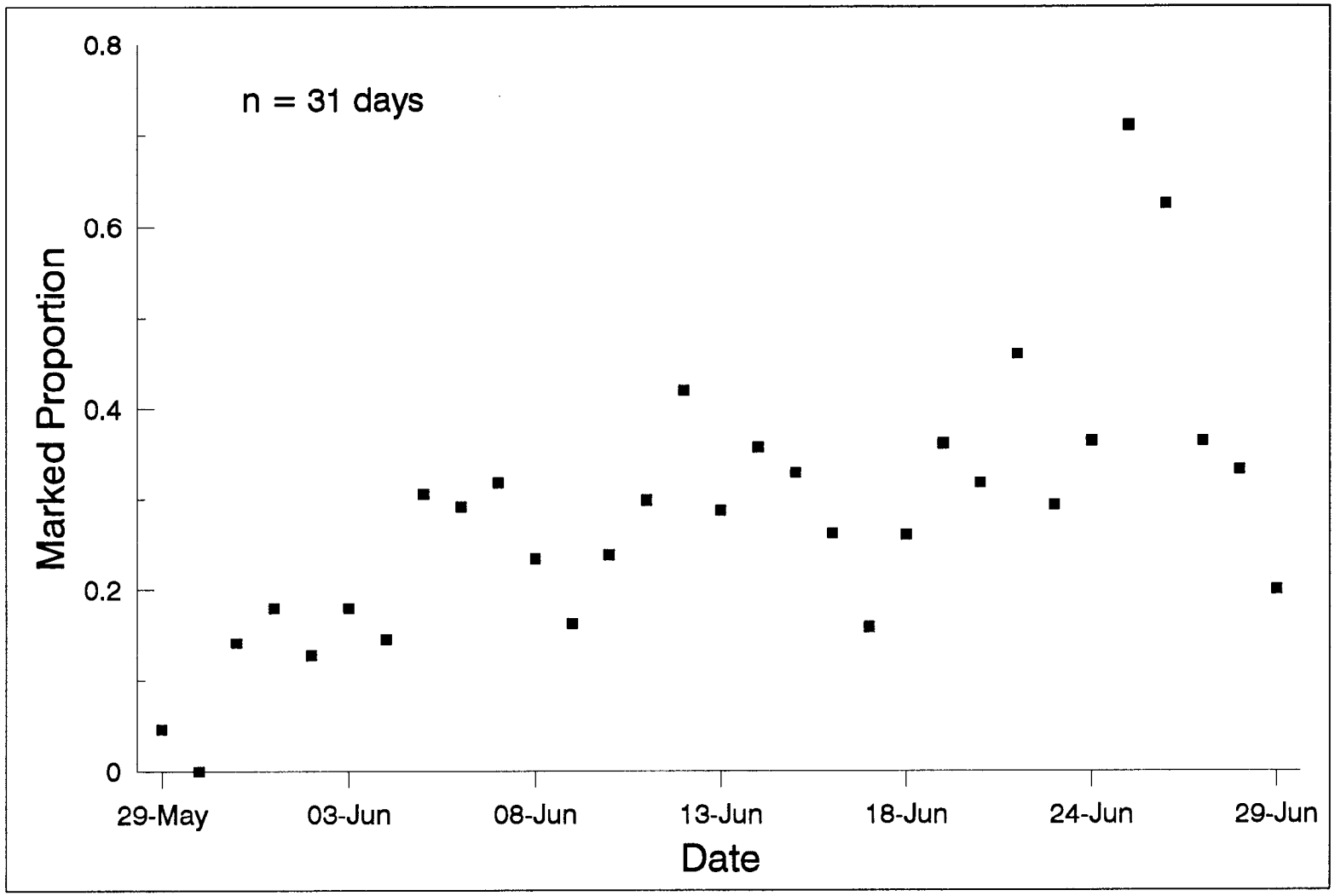

Figure 7. Daily proportion of adipose finclipped coho salmon smolt captured in inclined-plane traps at rkm 32.0 of the Kenai River, 1992.

Table 3. Age composition and mean length-at-age of coho salmon fingerling sampled from the Kenai River near the outlet of Skilak Lake, 22 August through 29 October 1991.

		Age-0				Age-1			
Sample Date	Sample Size	No.	%	Mean Length	SE	No.	%	Mean Length	SE
8/22/91	333	72	(22)	60	1.4	261	(78)	95	0.7
9/10/91	354	228	(64)	61	0.5	126	(36)	93	1.4
9/30/91	345	267	(77)	63	0.4	78	(23)	111	2.3
10/16/91	358	325	(91)	60	0.3	33	(9)	91	3.3
10/29/91[a]	399	339	(85)	62	0.4	60	(15)	95	1.7
Total	1,789[b]	1,231	(69)			558	(31)		

[a] Sampling took place on 2 days, 10/28/91 and 10/29/91.

[b] An additional 15 age-2 fish were sampled between 9/30/91 and 10/29/91.

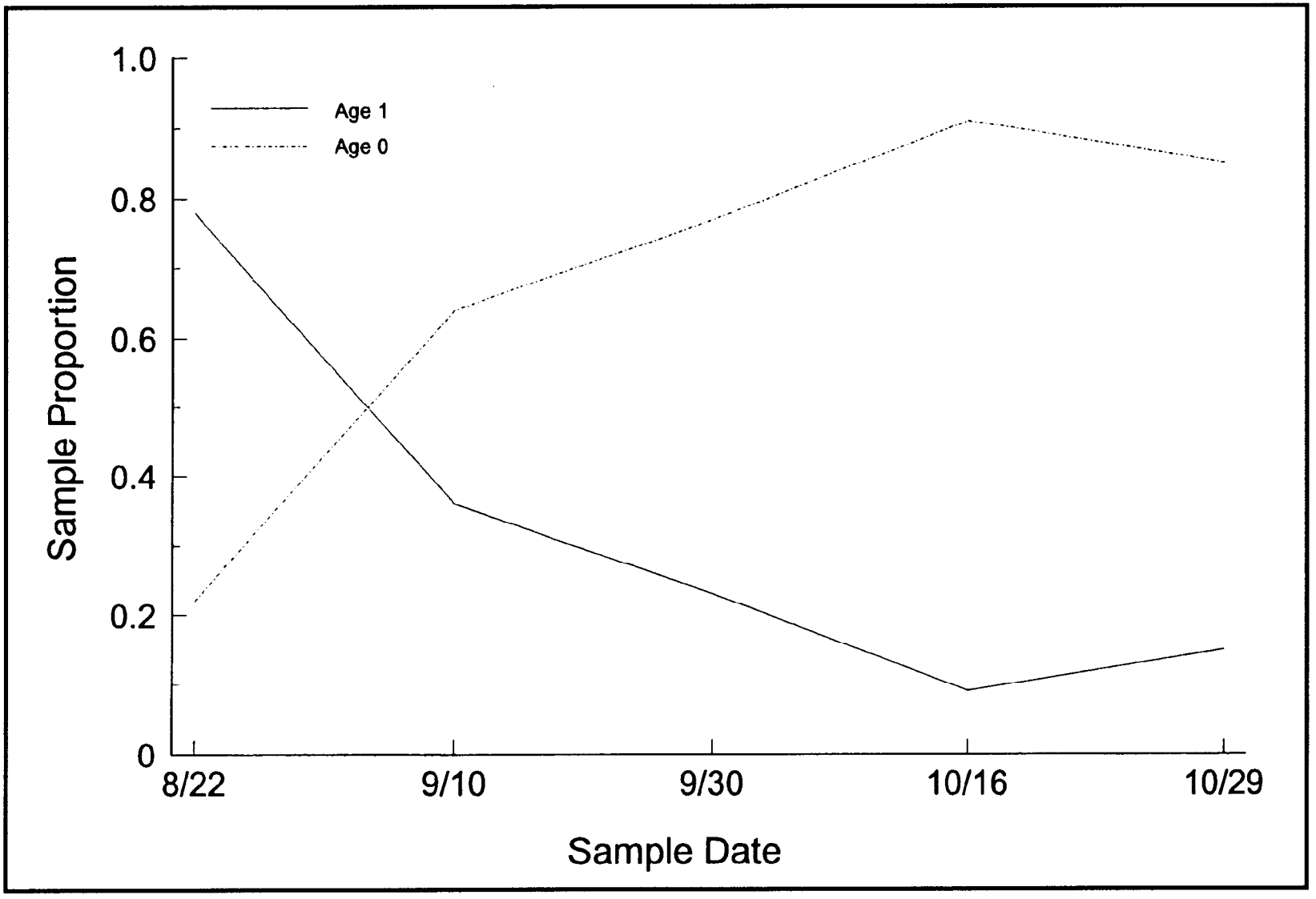

Figure 8. Proportion of age-1 and age-0 coho salmon sampled at the outlet of Skilak Lake between 22 August and 29 October 1991.

Table 4. Age composition of coho salmon smolt sampled at three locations in the Kenai River watershed from May-July, 1992.

Location	Time Period	Age 1	2	3	4
Hidden Creek	17 May-25 May	7.5	2.2	45.2	45.2
	5 June-13 June	0.3	89.9	9.9	
	14 June-19 June	4.8	92.6	2.6	
	20 June- 2 July	12.2	85.0	2.8	
	Total	6.1	83.6	7.9	2.4
Moose River	26 May- 2 June	1.7	92.9	5.4	
	5 June-13 June	2.5	89.5	7.9	
	14 June-19 June	2.0	94.0	4.0	
	20 June- 2 July	5.3	88.3	6.4	
	Total	3.0	91.0	6.0	
Kenai rkm 32.0 Traps	17 May-25 May		100.0		
	26 May- 2 June	7.0	87.4	5.6	
	14 June-19 June	11.6	86.3	2.2	
	20 June- 2 July	7.8	88.7	3.5	
	Total	8.9	87.3	3.8	

Table 5. Estimated number and percentage of coho salmon smolt emigrating from Hidden Creek and the Moose River during May through July, 1992.

			Age								
	Date		1		2		3		4		
Site	Begin	End	N	%	N	%	N	%	N	%	Total
Hidden[a] Creek	5/16	5/25	15	7.5	4	2.2	92	45.2	92	45.2	203
	5/26	7/06	2,118	5.9	31,631	88.1	2,154	6.0			35,903
		Total	2,134	5.9	31,635	87.6	2,246	6.2	92	0.3	36,106
Moose River	5/22	6/24	4,865	3.0	147,557	91.0	9,729	6.0			162,150

[a] Tag code 312131 was injected between 5/16-5/25 with all other codes injected after 5/25 at Hidden Creek.

Table 6. Mean length-at-age and associated standard error of coho salmon smolt sampled at three locations in the Kenai River drainage from May-July, 1992.

Location	Time Period	Age 1 n	Age 1 Mean Length	Age 1 SE	Age 2 n	Age 2 Mean Length	Age 2 SE	Age 3 n	Age 3 Mean Length	Age 3 SE	Age 4 n	Age 4 Mean Length	Age 4 SE
Hidden Creek	17 May–25 May	6	76	2.6	2	104	24.5	42	231	3.4	42	241	3.3
	5 June–13 June	2	112	13.5	656	143	0.7	72	189	5.4			
	14 June–19 June	11	119	1.8	214	132	0.5	6	167	22.0			
	20 June– 2 July	88	122	0.9	611	130	0.3	20	147	6.8			
	Total	107	119	1.3	1,483	136	0.4	140	195	4.0	42	241	3.3
Moose River	26 May– 2 June	4	106	3.0	224	118	0.7	13	145	6.8			
	5 June–13 June	6	112	3.1	214	124	0.8	19	147	4.8			
	14 June–19 June	4	120	5.4	189	122	0.6	8	134	5.2			
	20 June– 2 July	15	113	2.7	249	129	0.8	18	155	3.3			
	Total	29	113	1.8	876	123	0.4	58	147	2.6			
Kenai River rkm 32.0	17 May–25 May				1	112							
	26 May– 2 June	20	95	1.9	250	114	0.6	16	132	2.6			
	14 June–19 June	32	99	1.5	239	115	0.7	6	124	4.1			
	20 June– 2 July	11	108	2.7	125	116	0.8	5	133	3.4			
	Total	63	99	1.2	615	115	0.4	27	130	2.0			

Table 7. Mean length-at-age and standard error by pooled time periods of coho salmon smolt measured at three locations in the Kenai River drainage from May-July, 1992.

Site	Age	Time Period[a] Begin	End	Length No.	Mean	SE	Tag codes[b]
Hidden Creek	1	5/17	5/25	6	76	2.65	312131
		5/26	7/06	103	122	0.87	All other codes
	2	5/17	5/25	2	104	24.50	312131
		5/26	7/06	1,541	137	0.38	All other codes
	3	5/17	5/25	42	231	3.44	312131
		5/26	7/06	105	183	4.75	All other codes
	4	5/17	5/25	42	241	3.34	312131
Moose River	1	5/22	6/24	29	113	1.81	All codes
	2	5/22	6/05	224	118	0.70	312132, 312124, 312125, 312126, 312127, 312133, 312112, 312113, 312114, 312115
		6/06	6/19	403	123	0.51	312019, 312020, 312021, 312022
		6/20	6/24	249	129	0.85	312023
	3	5/22	6/24	58	147	2.62	All codes
Kenai River rkm 32.0	1	5/25	6/19	52	98	1.21	
		6/20	6/30	11	108	2.70	
	2	5/25	6/30	615	115	0.41	
	3	5/25	6/30	27	130	1.95	

[a] Time periods within which mean lengths did not differ ($P > 0.05$).

[b] Tag codes injected during time period.

the Moose River which, in turn, were larger than those captured at the rkm 32.0 traps (Table 6 and Figure 9).

There was a significant difference ($D = 0.34$, $n_1 = 1,009$, $n_2 = 458$, $P < 0.001$) between the cumulative length distribution of all smolt measured at the Moose River and marked Moose River smolt recaptured at the rkm 32.0 location (Figure 10). There was also a significant difference ($D = 0.47$, $n_1 = 1,883$, $n_2 = 36$, $P < 0.001$) using the same comparison for Hidden Creek smolt (Figure 10).

There were significant differences (range $t = -6.59$--8.27, $P \leq 0.0001$) in mean length-at-age of discrete tag code groups between release and recovery at rkm 32.0 for all code groups with > 5 recoveries except one (Table 8). In all cases, the mean length-at-recapture was smaller than the mean length-at-release.

DISCUSSION

Bias in Marked Populations

A marked population of coho salmon juveniles emigrated from the Kenai River in 1992 and will return as adults to spawn in 1993. The marked smolt originated from one of three locations: (1) the Skilak Lake outlet, (2) the Moose River, and (3) Hidden Creek.

The feasibility of using such a marked population to estimate commercial harvest of Kenai River coho salmon will be tested by examining the return of adults in 1993. A temporal change in the marked proportion returning to the river will confound an estimate of commercial contribution (J. H. Clark, Alaska Department of Fish and Game, Juneau, personal communication). With a sufficient recovery effort, both in the marine commercial harvest and the inriver sport harvest, the return timing of marked fish will reveal if there is timing bias associated with any of the original capture locations. If necessary, alternative juvenile capture strategies will be investigated.

If "stocks" of juveniles remain discrete throughout the duration of freshwater residence, then localized capture methods may not result in marking a population representative of all return timings. The dispersion of fingerling marked at Skilak Lake in 1991 indicates that populations of juveniles do mix within the drainage. All five tag codes released at the Skilak Lake location were represented by smolt recaptured at the Moose River and Hidden Creek. If random mixing occurs drainage-wide, then marking representatives of all return timings may indeed be possible with the localized capture strategies used to date.

Although the recapture of Skilak Lake marks indicates some degree of mixing, inherent size differences between the two tributary populations indicate some degree of isolation. Hidden Creek emigrants were larger at age than Moose River emigrants. There is the potential for a timing bias in the marking of isolated rearing groups.

To diminish sampling bias associated with run timing, it is desirable to mark a constant proportion of the smolt emigration over time. This would ensure

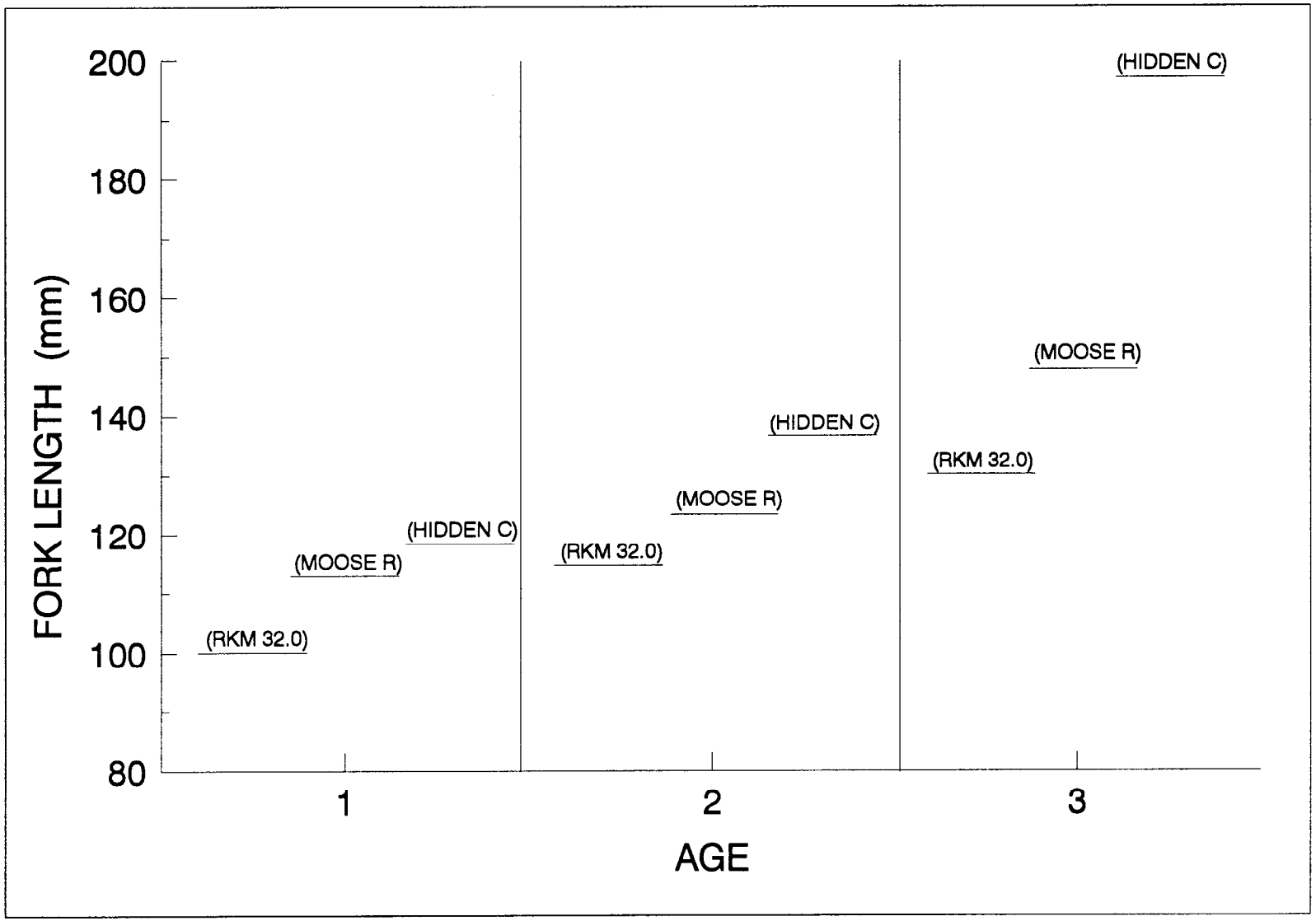

Figure 9. Mean length-at-age for coho salmon smolt sampled at three locations in the Kenai River drainage, 1992. Standard errors of all mean values were less than 3 mm.

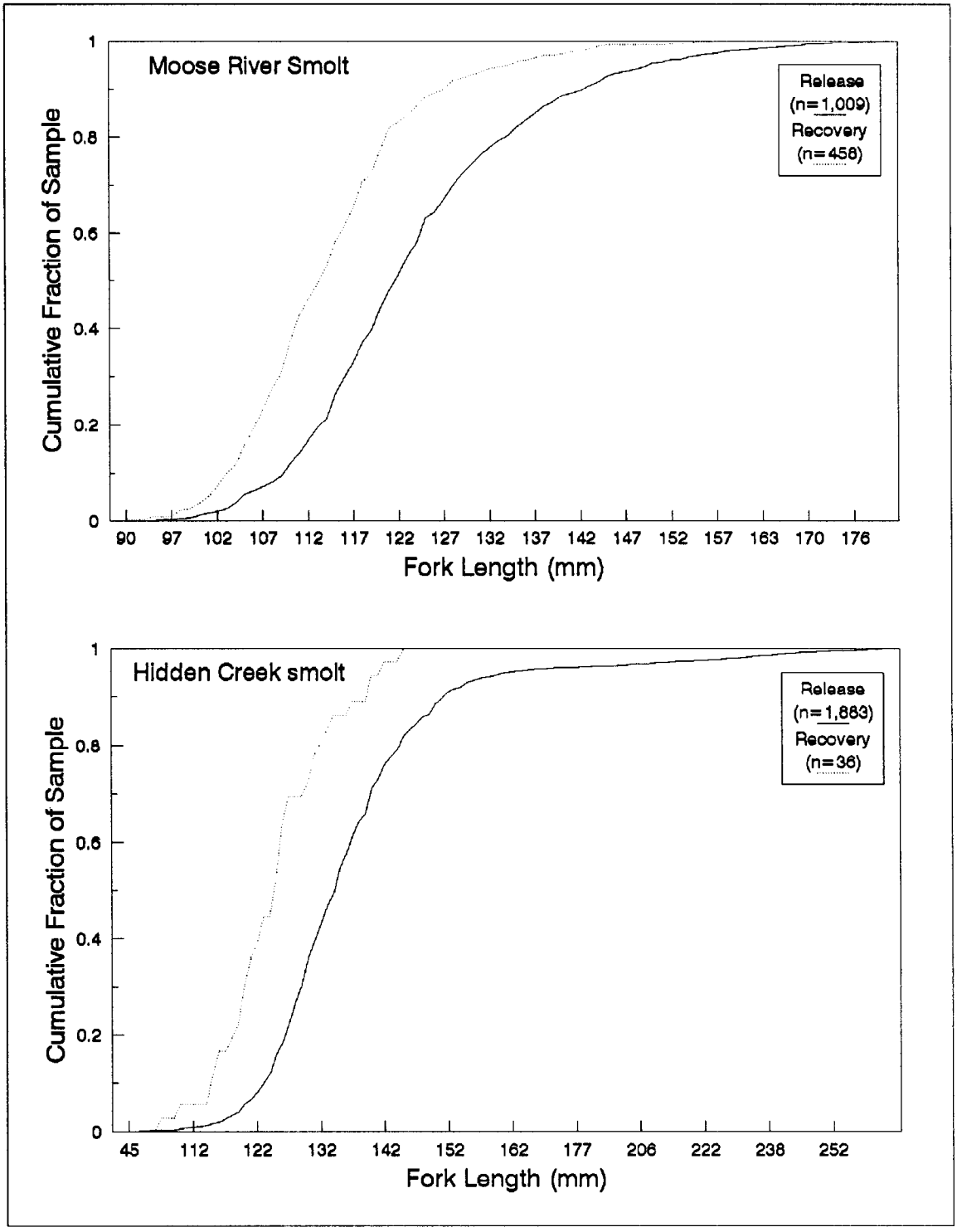

Figure 10. Comparisons of cumulative length frequencies for smolt marked at Moose River and Hidden Creek weirs and recovered at rkm 32.0 in the mainstem Kenai River, 1992.

Table 8. Comparisons of length-at-age between release and recapture for coho salmon smolt released at Hidden Creek and Moose River and recaptured at Kenai River rkm 32.0, 1992.

Tag group[a]	Age	Number Sampled at Release	Number recaptured at rkm 32.0	Mean length at release (mm)	Mean length at recapture (mm)	T	P
Hidden Cr. all codes except 312131	2	1,541	26	137	124	-7.3051	<0.001
Moose R. all codes	1	29	3	113	106	-1.2283	0.23
Moose R. codes 312112-312115, 312123-312127, 312132, 312133	2	224	52	117	115	-1.6993	0.09
Moose R. codes 312019-312022	2	403	70	123	114	-6.5872	<0.001
Moose R. code 312023	2	249	21	129	114	-8.2666	<0.001
Moose R. all codes	3	58	2	147	126	-1.5272	0.13

[a] Tag groups or ages not included in this table did not have at least two aged fish in the release or recapture.

that representatives of all return timings were marked in proportion to their abundance. The increasing trend in the marked proportion of smolt captured at rkm 32.0 indicates that this was not achieved for the 1992 emigration. However, it is not known if this trend will manifest itself in the return timing of adults.

The inclined-plane traps at rkm 32.0 are a proven coho salmon smolt capture gear. However, comparisons of length frequencies between release and recapture at rkm 32.0 indicate that the traps are size-selective. Inclined-plane trap catches of coho salmon smolt were biased toward small fish. Although their location in the drainage avoids the issue of sampling bias due to localized capture of isolated groups, the size-selectivity introduces a different source of bias. In their current configuration, they cannot be relied upon to intercept a representative sample of Kenai River coho salmon smolt.

Planning Tag Recovery Effort

The release of marked fish at upstream locations and the subsequent estimate of a marked proportion recovered at a downstream location offers an opportunity to generate an estimate of smolt abundance. This would be of value for planning the sampling effort required to estimate contribution of Kenai River coho salmon to the commercial fishery with an adequate degree of precision and accuracy. However, a smolt estimate was not generated during this first year of the study because violations of applicable mark-recapture models could not be adequately tested. In addition, indications that the rkm 32.0 traps may be size selective precludes the use of the overall marked proportion of 0.24 measured there in estimating the 1992 Kenai River smolt abundance.

Excessive and unexpected long-term tag loss will affect the precision and accuracy of contribution estimates (Clark and Bernard 1987). Although short-term tag retention rates measured during tag deployment at Skilak Lake were high, long-term retention rates measured for these fish recovered at Hidden Creek and the Moose River were low. Assuming no natural adipose fin loss, the marked fish found emigrating from Hidden Creek indicated a 19% tag loss rate and those found emigrating from the Moose River indicated a 21% tag loss rate. This approximate 20% loss rate primarily applies to the life stage between age-1 fingerling and smolt.

RECOMMENDATIONS

1. For planning purposes, the design of the 1993 commercial harvest sampling scheme should assume that approximately 24% of the smolt emigration was adipose-clipped. The number to be examined in the commercial harvest should be adjusted to account for a possible 20% tag loss rate.

2. Design a mark-recapture experiment to estimate total smolt emigration upon completion of the emigration. This would provide more complete information with which to plan adult tag recovery efforts.

3. Marking of juveniles at the Moose River, Hidden Creek, and the Skilak Lake outlet should continue until an evaluation of the methods is available by examining the 1993 adult return.

4. Continue to investigate smolt capture methods that intercept smolt in the mainstem as close to the river mouth as is practical. This may offer the best opportunity to capture and mark a representative sample of all Kenai River coho salmon.

5. Design an experiment to determine the rate of microwire tag loss between juvenile and adult life stages. A tertiary mark, such as an adipose tissue implant tag, should be considered for this purpose. This would allow recognition of control and treatment groups.

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APPENDIX A

Appendix A1. Summary of recoveries of marked coho salmon by date at Moose River and Hidden Creek, 1992.

1992 Date	Moose River Recoveries: Number Examined	Number Missing Adipose Fin	Number Dissected	Number Without Tag	Tags Decoded: Skilak Lake Releases, 1991: 31201	312015	312016	312017	312018	Moose River Releases, 1992[a]: 312132	312125	312127
05/22	186	1	1	1								
05/23	156	2	2				1	1				
05/24	1,790	12	12	2	1	2	4	3				
05/25	2,450	19	19	2	4	6	6	1				
05/26	1,459	33	33	9	8	7	7	2				
05/27	3,214	35	35	3	10	5	14	1	1	1		
05/28	3,458	18	11	4	2	2	1				2	
05/29	2,772	5	1		1							
05/30	3,648	49	12	4	2	4	2					
05/31	5,963	89	16	3	6	2	5					
06/01	3,442	59	10	3	1	3	2	1				
06/02	6,660	92	16		1	6	5	3				1
06/03	4,045	58	11	1	2	4	3	1				
06/04	4,525	60	6	1	1	1	1	2				
06/05	3,267	35	4		1		2					1
06/06	3,069	67	6	5				1				
06/07	616	6	1		1							
06/08												
06/09	3,276	69	6	2	2	2						
06/10	4,078	84	8	1	4		2		1			
06/11	3,635	56	5	1	2		2					
06/12	2,467	65	5	1	3		1					
06/13	2,493	55	5	3		1	1					
06/14												
06/15												
06/16	1,099	22	2	1				1				
06/17	1,559	35	3	1		2						
06/18												
06/19	2,467	61	6		2	1	2					
06/20	1,521	28	2			1		1				
06/21	673	15	1	1								
06/22												
06/23	690	24	2	1			1					
06/24	694	23	2									
Totals	75,372	1,177	243	50	54	49	62	18	2	1	2	2

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Appendix A1. (Page 2 of 2).

1992 Date	Hidden Creek Recoveries: Number Examined	Number Missing Adipose Fin	Number Dissected	Number Without Tag	Tags Decoded: Skilak Lake Releases, 1991: 31201	312015	312016	312017	312018	Hidden Creek Releases, 1992[b]: 312123	312030	312031
05/19	47											
05/20	4											
05/21	9											
05/22	10											
05/23												
05/24	50											
05/25[c]												
05/26[c]												
05/27[c]												
05/28[c]												
05/29[c]												
05/30[c]												
05/31[c]												
06/01[c]												
06/02[c]												
06/03[c]												
06/04[c]												
06/05[c]												
06/06[c]												
06/07[c]												
06/08	311	3	3	1			2					
06/09	621	1	1		1							
06/10	1,111	6	6	3			3					
06/11	1,778	8	8	1	1	1	2	2	1			
06/12												
06/13												
06/14	2,797	10	10	1	1	2	3	3				
06/15	1,868	6	6	2			3	1				
06/16	2,183	5	5	1	2		1			1		
06/17	2,114	5	5	1		2	2					
06/18	1,006	7	7		1		4	1		1		
06/19												
06/20												
06/21	1,530	10	10		3	1	3	2			1	
06/22	783	4	4	1	1	1			1			
06/23	1,402	5	5		2		3					
06/24	1,205	3	3	1	1		1					
06/25	428											
06/26												
06/27												
06/28	1,803	8	8	2	3		1				1	1
06/29	329	2	2	1			1					
06/30	384	2	2	1				1				
Totals	21,773	85	85	16	16	7	29	10	2	2	2	1

[a] These fish were marked and released at Moose River and apparently found a hole in the weir and returned upstream after release.

[b] These fish were marked and released at Hidden Creek and apparently found a hole in the weir and returned upstream after release.

[c] Fish were not examined or marked on these dates while field personnel assisted with marking at Moose River.

Appendix A2. Summary of recoveries of marked coho salmon by date at the Kenai River rkm 32.0 inclined-plane traps, 1992.

1992 Date	Number Examined	Number Missing Adipose Fin	Number Dissected	Number Without Tag	Moose River Tags Recovered													
					312132	312124	312125	312126	312127	312133	312112	312113	312114	312115	312019	312020	312021	312022	312023
05/16	1	0																	
05/17	3	0																	
05/18	2	0																	
05/19	1	0																	
05/20	1	0																	
05/21	0																		
05/22	0																		
05/23	0																		
05/24	2	0																	
05/25	0																		
05/26	17	0																	
05/27	14	0																	
05/28	26	0																	
05/29	65	3	3	0		3													
05/30	49	0																	
05/31	135	19	19	2	2	3	11	1											
06/01	234	42	42	0	3	8	14	10	5										
06/02	434	55	54	1		6	7	4	30	1									
06/03	123	22	22	0	1	2		3	3	2	6	5							
06/04	165	24	24	2				1	1	1	5	14							
06/05	252	77	75	3		1	2	5	2		12	26	17						
06/06[a]	96	28	6	0							1	1	3	1					
06/07[a]	176	56	9	1		1			1				1	4	1				
06/08[a]	231	54	11	1			2				1	1	2	1	3				
06/09[a]	210	34	6	1									2	2	1				
06/10[a]	143	34	4	1			1					1		1					
06/11[a]	144	43	9	0			1						1		3	4			
06/12[a]	138	58	12	0									1			4	6		
06/13	160	46	46	3										1		18	20		
06/14[b]	126	45	86	6				2	1		1	1	1		1	14	42	11	
06/15[b]	82	27																	
06/16[b]	65	17																	
06/17	19	3	3	1															
06/18	50	13	13	9														3	
06/19	36	13	13	0								1			1			8	
06/20	22	7	7	0														7	
06/21[c]	32	40	40	4									1					21	11
06/22[c]	55																		
06/23	17	5	5	0											1				2
06/24	22	8	8	0															6
06/25	45	32	32	17									1					1	8
06/26	16	10	10	2														1	7
06/27	11	4	4	0															1
06/28	42	14	14	0															1
06/29	10	2	2	1															1
06/30	3	3	3	0			1												
Totals	3,475	838	582	55	6	24	39	26	43	4	26	50	30	11	11	40	68	52	37

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1992 Date	Number Examined	Number Missing Adipose Fin	Number Dissected	Number Without Tag	Hidden Creek Tags Recovered					Skilak Lake Tags Recovered			
					312134	312123	312030	312031	312032	312014	312015	312016	312017
05/16	1	0											
05/17	3	0											
05/18	2	0											
05/19	1	0											
05/20	1	0											
05/21	0												
05/22	0												
05/23	0												
05/24	2	0											
05/25	0												
05/26	17	0											
05/27	14	0											
05/28	26	0											
05/29	65	3	3	0									
05/30	49	0											
05/31	135	19	19	2									
06/01	234	42	42	0							1		1
06/02	434	55	54	1						2	2	1	
06/03	123	22	22	0									
06/04	165	24	24	2									
06/05	252	77	75	3						2	1	2	2
06/06[a]	96	28	6	0									
06/07[a]	176	56	9	1									
06/08[a]	231	54	11	1									
06/09[a]	210	34	6	1									
06/10[a]	143	34	4	1									
06/11[a]	144	43	9	0									
06/12[a]	138	58	12	0									
06/13	160	46	46	3	2					1		1	
06/14[b]	126	45	86	6		3					1	1	
06/15[b]	82	27										1	
06/16[b]	65	17											
06/17	19	3	3	1		1				1			
06/18	50	13	13	9		1							
06/19	36	13	13	0		2				1			
06/20	22	7	7	0									
06/21[c]	32	40	40	4			2	1					
06/22[c]	55												
06/23	17	5	5	0		1	1						
06/24	22	8	8	0				2					
06/25	45	32	32	17			2	3					
06/26	16	10	10	2									
06/27	11	4	4	0				2			1		
06/28	42	14	14	0			1	11	1				
06/29	10	2	2	1									
06/30	3	3	3	0				1	1				
Totals	3,475	838	582	55	2	8	6	20	2	7	6	6	3

[a] From 6/6 through 6/12 approximately 20% of the number of fish missing an adipose fin were systematically retained for dissection.

[b] From 6/14 through 6/16 the number examined and number missing adipose fin are correct by date. However, date information is missing for number dissected. Tag decoding results for fish recovered over these 3 days were pooled and listed under 6/14.

[c] From 6/21 through 6/22 the number examined is correct by date. However, date information is missing for number missing adipose fin. Tag decoding results from these 2 days were pooled and listed under 6/21.